International Journal of Occupational Medicine and Environmental Health, Vol. 14, No. 2, 189—192, 2001

REFERENCE VALUES FOR LEAD AND CADMIUM IN BLOOD OF CZECH POPULATION*

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Abstract. This study aimed at determining blood concentrations of lead (B-Pb) and cadmium (B-Cd) in a group of 1215 healthy blood donors (895 males, 320 females) and 758 children (397 boys, 361 girls) aged 10 years, sampled in 1996–1998 in four districts of the Czech Republic. The analysis was performed using atomic absorption spectrometry. The median B-Pb values were lower in children (34 mg/L) than in adults. In the group of adults, the level was significantly higher in men (46 mg/L) than in women (29 mg/L). In none of the groups the 90th percentile exceeded the value of 100 mg/L. The B-Cd values in adults depended on smoking habit (median non-smokers: 0.5 mg/L, male smokers – 1.2 mg/L, female smokers – 1.0 mg/L). In children, more than 50% of values were under the limit of detection. The obtained values were used to propose reference values for the Czech population.

Key words:
Biological monitoring, Blood, Lead, Cadmium, Reference values

Lead and cadmium are two heavy metals of wide occupational and environmental concern. Both metals are present in an amazing variety of environmental media. The measurement of metals in human specimens (biological monitoring) gives better assessment of exposure from multiple sources and routes. Biological monitoring evaluates internal doses, which are more related to possible health effects. Blood lead is a widely used parameter for an evaluation of individual lead exposure. Cadmium in blood may be used to assess recent exposure to this element. Biological monitoring has been applied in the System of Monitoring the Environmental Impact on the Population Health implemented in the Czech Republic since 1994. One of the aims of the biological monitoring was to propose the reference values for selected metals in human body fluids. The knowledge of reference values is essential for the interpretation of further biomonitoring data. In this paper, we propose reference values for the lead and cadmium in blood based on the results of biological monitoring system in the Czech Republic obtained during 1996–1998.

MATERIALS AND METHODS

Sample collection

The blood samples were collected in the years 1996–1998, each year in March through June, in four district cities, two of them representing industrial, and two recreational and agricultural living conditions. In adults, blood samples were obtained from blood donors (n = 1216; 896 males, 320 females; mean age 33.6 and 32.4 years, respectively), blood samples in children (n = 758; 397 boys, 361 girls; mean age

* The paper presented at the conference "Metal in Eastern and Central Europe: Health effects, sources of contamination and methods of remediation" , Prague, Czech Republic, 8-10 November 2000

The study was supported by the Government of the Czech Republic.

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Table 1. Blood lead concentrations (μg/L) in the population monitored since 1996 (all localities, ages and sexes)

Year	Group	No.	Median	90th percentile	Maximal value
1996	Adults	419	44.4	85.1	318
	Children	374	33.0	56.7	179
1997	Adults	400	39.0	74.9	180
	Children		Not monitored		
1998	Adults	395	40.0	71.0	197
	Children	384	34.0	50.0	179

9.9 years) were collected in schools by qualified health personnel. An informed consent was obtained from each donor and/or children's parents. For each person, the data on the age, sex, residential area, medication, in adults also on smoking status and occupation were recorded in a questionnaire. Blood sampling procedure was done according to the protocol designed to minimize trace element contamination. S-Monovette Sarsted Cat. No. 02.1065.400 blood sampling sets containing heparin as an anticoagulant agent and appropriate silicon-coated needles were used. Specimens were frozen at –20°C until analyzed.

ANALYSIS OF SAMPLES

After mineralization of blood samples in microwave system (milestone 1200 Mega, U.S.A.), Pb and Cd were determined by means of atomic absorption spectrometry (Perkin Elmer 4100 ZL with Zeeman's background correction). The accuracy was checked by means of reference materials (Control Material Seronorm Whole Blood 4040107 and Serum 704121).

The laboratory regularly takes part in the interlaboratory testing organized by the Institute and Out-Patient Clinic for Occupational, Social and Environmental Medicine at the University of Erlangen (Germany), as well as by IAEA and Ekocentrum, Ostrava, Czech Republic.

For the statistical analysis the Kruskal-Wallis test was used. The data below the limit of detection for the method were replaced by the half of the limit of detection values.

RESULTS

The results of blood lead and cadmium concentrations for overall population groups of adults and children sampled in the years 1996 through 1998 are shown in Tables 1 and 2, respectively. Table 1 gives blood lead (B-Pb) concentrations in whole blood of adults and children, obtained in 1996 through 1998. The results presented as median, 90th percentile and maximum concentration for each monitored year did not show any significant time-related differences within the monitored period. The 90th percentile in both children and adults did not exceed the value of 100 μg/L and the concentrations were lower in children than in adults. Table 3 shows the age- and sex-dependent differences in B-Pb with a significantly higher level in males ($p < 0.01$) than in females. An insignificantly higher level of B-Pb was observed in smokers than in non-smokers. In children, no sex-dependent differences were observed.

Table 2. Blood cadmium concentrations (μg/L) in the population monitored since 1996 (all localities, ages and sexes)

Year	Group	No.	Median	90th percentile	Maximal value
1996	Adults	419	0.80	1.90	10.6
	Children*	373	0.15	0.70	3.6
1997	Adults	402	0.60	1.60	6.6
	Children				
1998	Adults	394	0.60	1.57	5.5
	Children*	384	0.15	0.40	1.5

*More than 50% of values under the limit of detection (0.3 μ/L)

Table 3. Blood lead and cadmium levels in adults by age, sex and smoking habit

Group	Pb			Cd		
	No.	Median	90th perc.	No.	Median	90th perc.
Total	1214	41.0	76.0	1215	0.7	1.7
Males	894	46.0*	80.0	895	0.7	1.7
Male smokers	360	49.0	87.0	360	1.2*	2.3
Male non-smokers	534	45.0	76.0	535	0.5	1.0
Males aged <21 yrs	20	41.0	77.0	20	0.7	1.1
Males aged 21–30 yrs	345	44.0	75.0	345	0.6	1.6
Males aged 31–40 yrs	344	48.0	88.0	344	0.7	1.8
Males aged 41–50 yrs	185	49.0	78.0	186	0.7	1.8
Females	320	29.0	54.0	320	0.7	1.4
Female smokers	94	31.0	64.0	94	1.0	1.9
Female non-smokers	226	28.0	53.0	226	0.6	1.1
Females aged <21 yrs	24	25.0	39.0	24	0.5	1.1
Females aged 21–30 yrs	106	26.0	53.0	106	0.6	1.3
Females aged 31–40 yrs	121	30.0	62.0	121	0.7	1.4
Females aged 41–50 yrs	69	31.0	53.0	69	0.8	1.7

* $p < 0.01$ (males vs. females for Pb, male smokers vs. non-smokers for Cd)

The results of blood cadmium concentrations (B-Cd) are summarized in Table 2. In children, B-Cd level was low and in more than 50% of samples the level was below the limit of detection for the methods used. In adults, no substantial sex- and age differences were observed, but significantly higher values ($p < 0.01$) were obtained in smokers than in non-smokers (Table 3).

The results of both B-Pb and B-Cd obtained in 1215 adults and 758 children from four districts were used to propose the reference values for the Czech population (Table 4).

DISCUSSION

The levels of toxic metals in human body fluids and tissues represent an important indicator of the health status. The B-Pb concentrations in non-occupationally exposed persons monitored in this study were relatively low and even in male adults who represent the group with the highest concentration, the value of 95th percentile did not exceed 100 µg/L. The results showed no substantial time trend in B-Pb during the years 1996–1998 and did not differ from those obtained in 1995 [1]. Our data correspond well with those reported by the authors from other European coun-

Table 4. The proposed blood lead and cadmium reference values (µg/L) for the Czech population.

Group	Pb			Cd		
	Median	95th perc.	Reference value	Median	95th perc.	Reference value
Adults total	41.0	76.0		0.7	2.1	
Adult non-smokers				0.5	1.2	1.2
Adult males	46.0	95.0	95	0.7	1.9	
Adult females	29.0	78.0	80	0.7	2.2	
Children total (9–10 yrs)	34.0	61.0	65	0.15	0.8	0.8
Boys	35.0	63.0		0.15	0.8	
Girls	31.0	57.0		0.15	0.8	

tries; e.g. the mean B-Pb of 26 µg/L was reported for the Helsinki children in 1996 [2], 45.6 µg/L for the adult population in Barcelona [3], or median value of 45 µg/L for adults and 33 µg/L for children in Germany [4]. However, higher B-Pb values might still be found in the Czech population living in heavily contaminated industrial zones found around the Příbram lead smelter where mean B-Pb levels in school children were about 113.5 µg/L in 1992 [5]. Human environmental exposure to cadmium is widespread. Measurement of cadmium in blood is used to assess recent exposure to this element. Average B-Cd concentrations in adults (median: 0.7 µg/L in both sexes) were within the range of the values reported for the general population in other European countries [6]. Higher exposure has been reported in some countries outside Europe, particularly in Japan. [7]. The most important lifestyle factor regarding Cd intake is tobacco smoking. In this study, concentrations of B-Cd were almost doubled in smokers (median: 1.2 µg/L in males, 1.0 µg/L in females). In our population, B-Cd insignificantly increased with age. In children, the levels were low and in more than 50% of subjects the concentration was under the limit of detection (0.3 µg/L).

Reference values were derived from the population studies where the concentration of appropriate biomarker in body fluids had been measured in a representative part of the general population. Usually the 90th or 95th percentiles of the concentration values were determined from those studies and defined as reference values [8]. Our results obtained in well-defined population groups apparently met these criteria. The reference values were proposed separately for children and adults. In adults, the B-Pb reference values were defined separately for each sex group, and B-Cd reference values were established only for non-smokers, because the values differed between these groups according to age, sex and lifestyle factors.

In conclusion, the presented reference values may be a useful tool for the interpretation of results, especially of those for the environmental exposure.

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Received for publication: January 25, 2001
Approved for publication: May 15, 2001